Demystifying Loads for Building Officials

Based on the 2024 IBC® and ASCE 7-22

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GOAL & OBJECTIVES

Description

This 6-part webinar series will provide information to assist code officials during the plan review process on the proper evaluation of structural loads per the 2024 *International Building Code®* (IBC®) and the IBC-referenced 2022 ASCE/SEI 7 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 7-22). An overview of each topic along with changes that have occurred to the 2024 IBC and ASCE 7-22 will be provided as well as examples to show their application. The following topics will be presented:

- Load Path, Load Combinations and Risk Categories
- Dead, Live and Rain Loads
- Snow and Ice Loads
- Wind and Tornado Loads
- Earthquake Loads
- Flood and Tsunami Loads
- Temporary Structures

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GOAL & OBJECTIVES

Learning Objectives

- Understand proper evaluation of structural loads and associated criteria in the IBC and ASCE 7
- Identify changes to load provisions and associated criteria in the 2024 IBC and ASCE 7-22
- Describe examples to show application of provisions
- Determine additional available resources

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COURSE OUTLINE

- Load Path, Load Combinations and Risk Categories
- Dead, Live and Rain Loads
- Snow and Ice Loads
- Wind and Tornado Loads
- Earthquake Loads
- Flood and Tsunami Loads
- Temporary Structures

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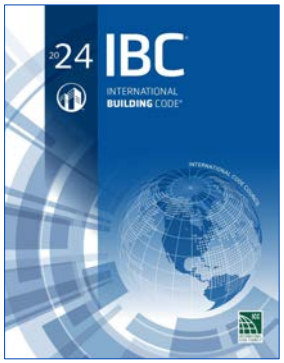
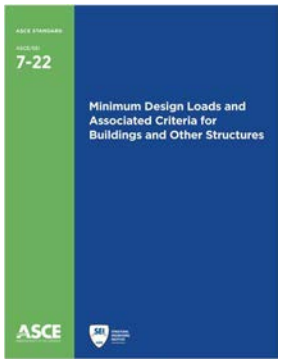
Codes and Standards





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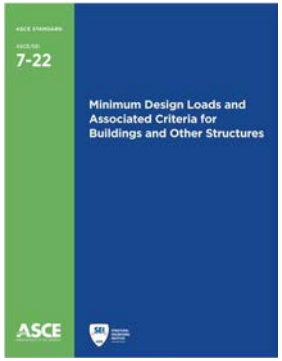
Structural Design Loads Changes

- Updated loads
  - All environmental loads
    - Moving to risk basis
  - Guards and handrails
- Tornado loads – new
  - Risk Category III & IV



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Resources

Available for use or that can be used for support or help

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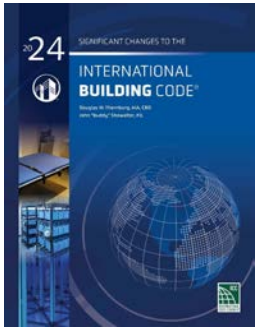
IBC Significant Changes



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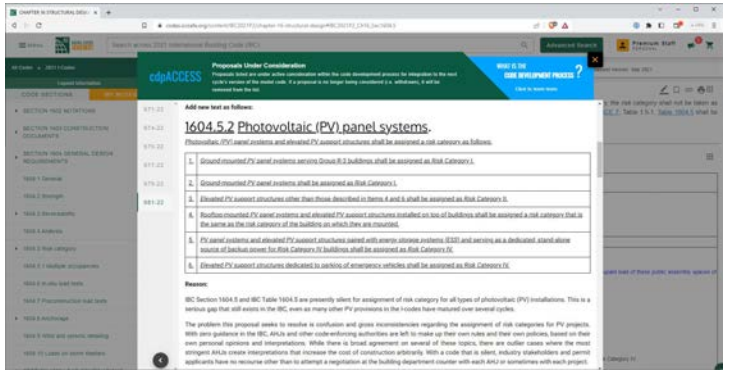
Digital Codes Premium



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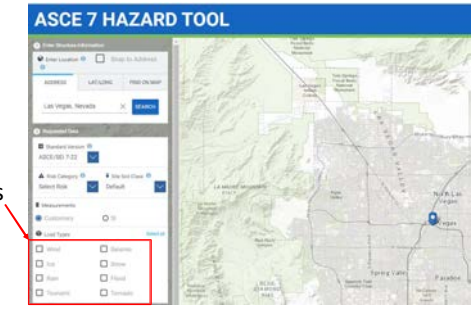
asce7hazardtool.online

- FREE
- Address or Lat/Long
- ASCE 7-10, 7-16 & 7-22
- Risk Category
- All environmental loads



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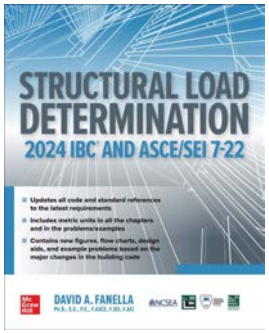
Textbook with Solved Examples



- Figures, flow charts, design aids, and example problems
- Loads: dead, live, rain, snow, ice, wind (including tornado), earthquake, flood and tsunami

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Webinar Series – ICC Learn Live

Demystifying Loads for Building Officials – 2024 IBC and ASCE 7-22

Topics in this series for 2024

• Load Path, Load Combinations and Risk Categories	June 12
• Dead, Live and Rain Loads	July 10
• Snow and Ice Loads	August 14
• Wind and Tornado Loads	September 11
• Earthquake Loads	October 9
• Flood and Tsunami Loads	November 13
• Temporary Structures	December 11

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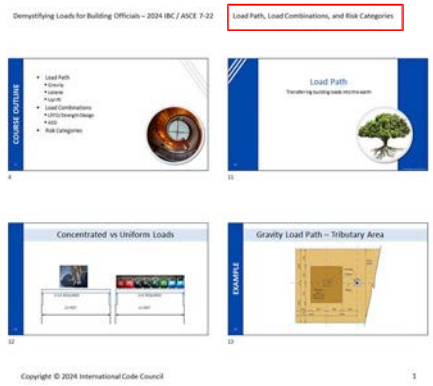
Handouts



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COURSE OUTLINE

- Load Path
  - Gravity
  - Lateral
  - Uplift
- Load Combinations
  - LRFD/Strength Design
  - ASD
- Risk Categories

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Load Path

Transferring building loads into the earth

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Concentrated vs Uniform Loads

2×10 REQUIRED

12 FEET

2×6 REQUIRED

12 FEET

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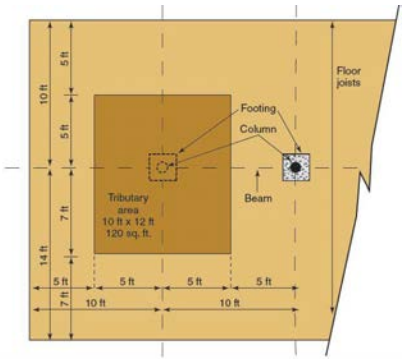
EXAMPLE

Gravity Load Path – Tributary Area



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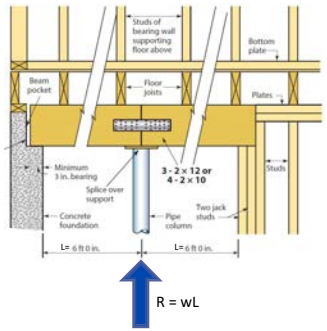
EXAMPLE

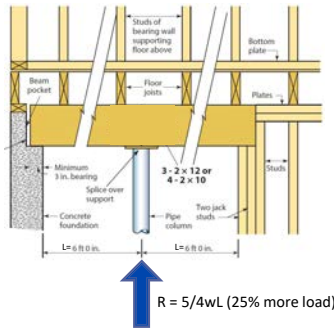
Gravity Load Path – Beam Spans

2 simple span beams



R = wL

Continuous multi-span beam



R = 5/4wL (25% more load)

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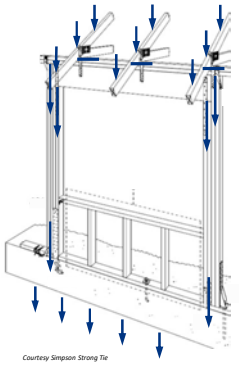
Gravity Load Path – Light Frame



Courtesy Simpson Strong Tie

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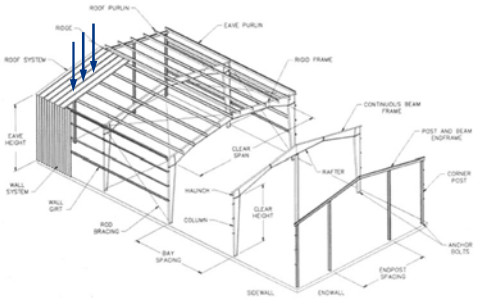
Gravity Load Path – Frame/Purlin Systems

1. Gravity load on roof sheathing
2. Transfer to walls and roof purlins
3. Load travels to rigid frame or walls to foundation



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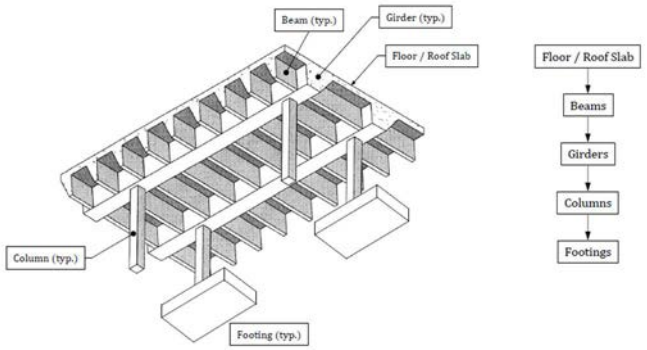
Gravity Load Path – Slab/Beam/Column Systems



Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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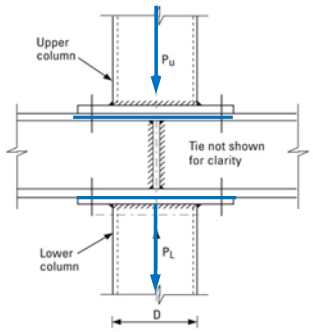
Gravity Load Path – Columns



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Gravity Load Path – Foundation

Footings

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Gravity Load Path – Foundation

Poles/piles

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Gravity Load Path – Foundation

Helical Piles

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Gravity Load Path – Foundation

- Deep
  - Driven
  - Cast-in-place

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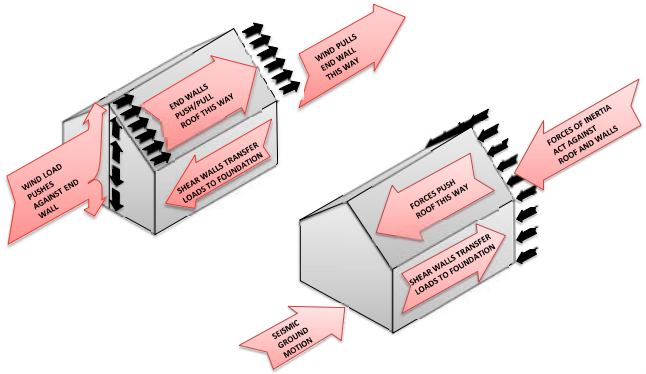
Lateral Load Path



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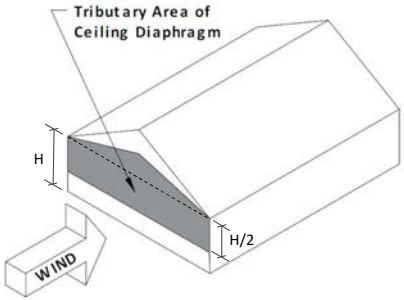
Lateral Load Path – Tributary Area



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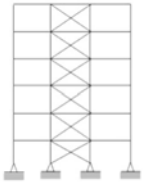
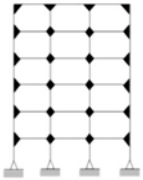
Building Systems

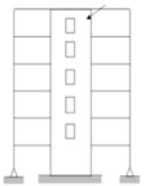
Braced Frame



Moment Frame



Bearing/Shear Wall



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Braced Frames

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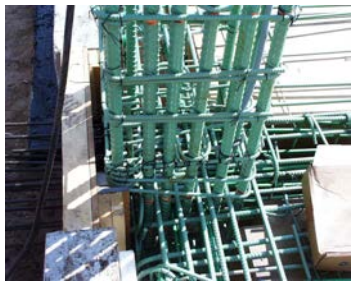
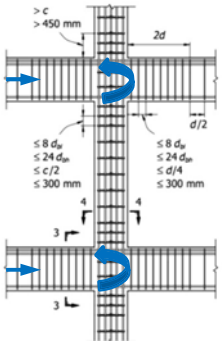
Moment Frames – Concrete





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Moment Frames – Steel

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Moment Frames – Steel

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Shear Walls

Masonry

Concrete

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Shear Walls

CFS Studs

Wood Studs

40

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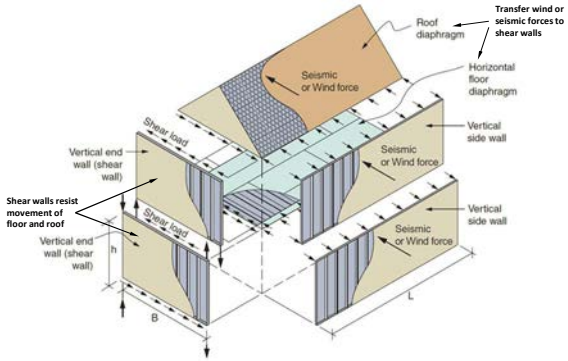
Lateral Load Path – Shear Walls & Diaphragms



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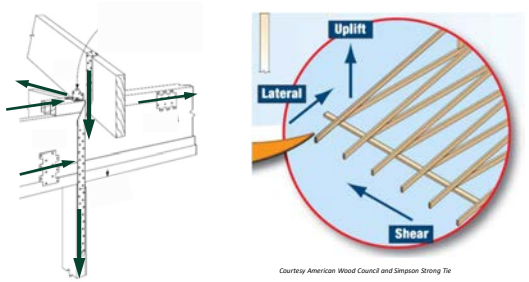
Load Path – Light-frame Roofs



Courtesy American Wood Council and Simpson Strong Tie

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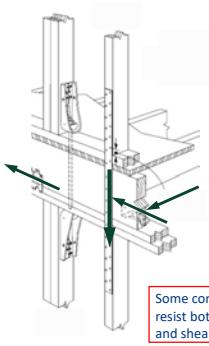
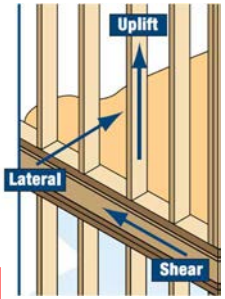
Load Path – Light-frame Walls



Some connectors resist both lateral and shear loads



Courtesy American Wood Council and Simpson Strong Tie

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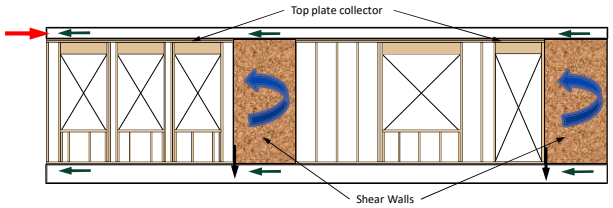
Load Path – Light-frame Shear Walls

- Roof or floor diaphragm collects loads
- Top plates "drag" load to shear walls
- Shear walls resist shear and overturning and transfer load to foundations



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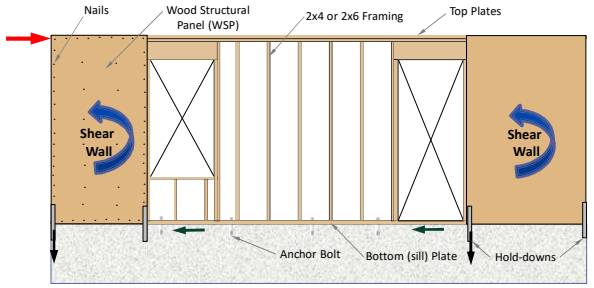
Seismic Load Path – Light-frame Shear Wall



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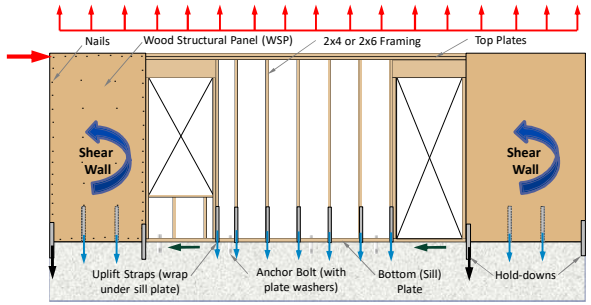
Wind Load Path – Light-frame Shear Wall



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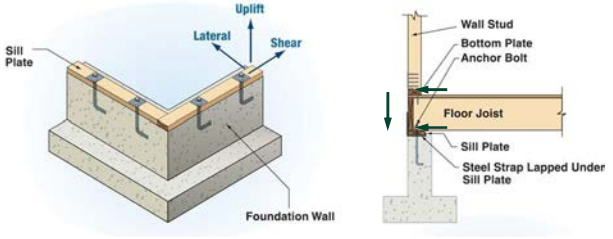
Load Path – Light-frame on Foundations



Some connectors resist both lateral and shear loads

Courtesy American Wood Council

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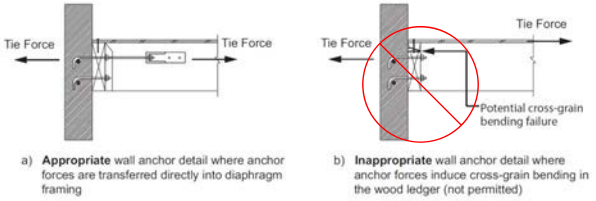
Lateral Load Path – Commercial Roofs

- High load roof diaphragms on tilt-up buildings



a) **Appropriate** wall anchor detail where anchor forces are transferred directly into diaphragm framing

b) **Inappropriate** wall anchor detail where anchor forces induce cross-grain bending in the wood ledger (not permitted)

Courtesy American Wood Council

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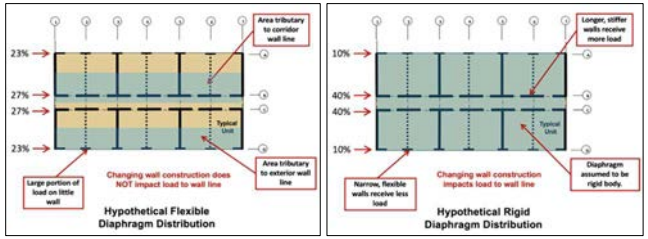
CODE CHANGE

1604.4 Rigid vs Flexible Diaphragms

- Envelope analysis – rigid and flexible separately
- Design components for most severe condition



Courtesy WoodWorks – Wood Products Council

IBC § 1604.4
ASCE 7 § 12.3

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APPLICATION

4. Wind load path in light frame construction needs to be considered in which direction(s)?

a. Lateral
b. Shear
c. Uplift
d. All of the above

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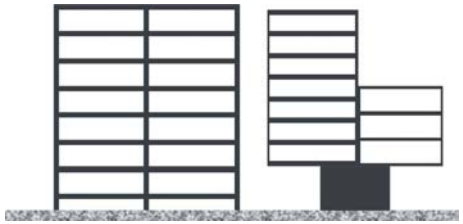
Irregular Buildings

Seismic Design



ASCE 7 § 12.3.2

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Load Combinations

Accounting for improbability of simultaneous maximum live loads

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Symbols

D = Dead load
L = Live load
L_r = Roof live load
R = Rain load
S = Snow load
W = Load due to wind pressure
W_T = Load due to tornado pressure
E = Combined effect of horizontal and vertical earthquake induced forces

Note: Other loads such as ice, flood, and soil not shown

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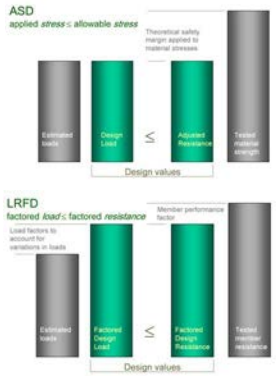
Load Combinations – ASD vs SD/LRFD

- ASD = allowable stress design
  - aka: working stress design
- SD = strength design
  - aka: LRFD
  - Concrete and masonry design
- LRFD = load and resistance factor design
  - Wood and steel design



IBC § 202
ASCE 7 § 1.2.1

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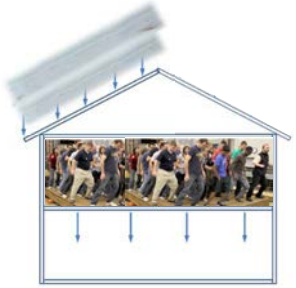
Load Combinations – What's the Point?

What's the probability of 100% snow load AND 100% floor live load?



Example Load Combinations

LRFD: 1.2D + 1.6L + 0.3S

ASD: D + 0.75L + 0.525S

IBC § 1605
ASCE 7 § 2.3 & 2.4

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Load combinations account for the improbability of simultaneous maximum live loads

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Load Combinations – LRFD/Strength Design (SD)

CODE CHANGE

1.4D	(Eq 1a)
1.2D + 1.6L + (0.5L_r or 0.3S or 0.5R)	(Eq 2a)
1.2D + (1.6L_r or 1.0S or 1.6R) + (L or 0.5W)	(Eq 3a)
1.2D + 1.0(W or W_T) + L + (0.5L_r or 0.3S or 0.5R)	(Eq 4a)
0.9D + 1.0 (W or W_T)	(Eq 5a)
1.2D + E_v + E_h + L + 0.15S	(Eq 6)
0.9D – E_v + E_h	(Eq 7)

IBC § 1605
ASCE 7 § 2.3

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CODE CHANGE

Load Combinations – ASD

D	(Eq 1a)
D + L	(Eq 2a)
D + (L_r or 0.7S or R)	(Eq 3a)
D + 0.75L + 0.75(L_r or 0.7S or R)	(Eq 4a)
D + 0.6(W or W_T)	(Eq 5a)
D + 0.75L + 0.75(0.6(W or W_T)) + 0.75(L_r or 0.7S or R)	(Eq 6a)
0.6D + 0.6(W or W_T)	(Eq 7a)
D + 0.7E_v + 0.7E_h	(Eq 8)
D + 0.525E_v + 0.525E_h + 0.75L + 0.1S	(Eq 9)
0.6D − 0.7E_v + 0.7E_h	(Eq 10)

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IBC § 1605
ASCE 7 § 2.4

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CODE CHANGE

Load Combinations – Alternative ASD

D + L + (L_r or 0.7S or R)	(Eq 16-1)
D + L + 0.6W	(Eq 16-2)
D + L + 0.6W + 0.7S/2	(Eq 16-3)
D + L + 0.7S + 0.6W/2	(Eq 16-4)
D + L + 0.7S + E/1.4	(Eq 16-5)
0.9D + E/1.4	(Eq 16-6)

- Where design for tornado loads is required, the alternative allowable stress design load combinations of Section 1605.2 shall not apply when tornado loads govern the design.

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IBC § 1605.2
& 1605.1 Exception 4

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APPLICATION

6. Load combinations account for the improbability of simultaneous maximum live loads?

a. True
b. False

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Risk Categories

Building classification based on hazard to life for determining load magnitudes

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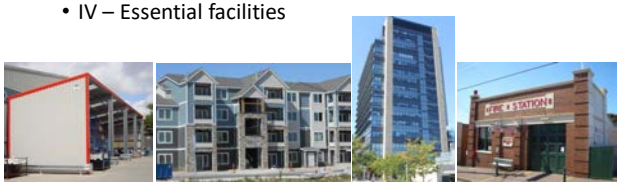
Risk Category (RC)

- I – Low hazard to human life
- II – Ordinary buildings (not RC I, III or IV)
- III – Substantial hazard to human life
- IV – Essential facilities



I II III IV

IBC § 1604.5
ASCE 7 § 1.5

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ASCE 7-22 Risk Categories

Table 1.5-1.
Risk Category of Buildings and Other Structures for Flood, Wind, Tornado, Snow, Earthquake, and Ice Loads.

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent low risk to human life in the event of failure	I
All buildings and other structures except those listed in Risk Categories I, III, and IV	II
Buildings and other structures, the failure of which could pose a substantial risk to human life	III
Buildings and other structures not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure	
Buildings and other structures not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released*	
Buildings and other structures designated as Essential Facilities	IV
Buildings and other structures, the failure of which could pose a substantial hazard to the community	
Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released*	
Buildings and other structures required to maintain the functionality of other Risk Category IV structures	

* Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for classification to a lower risk category if it can be demonstrated to the satisfaction of the Authority Having Jurisdiction by a hazard assessment as described in Section 1.5.3 that a release of the substances is commensurate with the risk associated with that risk category.

73

73

2024 IBC Risk Categories

TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Risk Categories I, III and IV.

No changes to RC I & II

74

74

2024 IBC Risk Categories

CODE CHANGE

Moved to RC IV

Risk Category	Nature Of Occupancy
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • ~~Group I-2, Condition 1 occupancies with 50 or more care recipients.~~ • ~~Group I-2, Condition 2 occupancies not having emergency surgery or emergency treatment facilities.~~ • Group I-3, Condition 1 occupancies. • Any other occupancy with an occupant load greater than 5,000.[a] • Power-generating stations with individual power units rated 75 MW_{ac} (megawatts, alternating current) or greater, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV.

a. For purposes of occupant load calculation, occupancies required by Table 1004.5 to use gross floor area calculations shall be permitted to use net floor areas to determine the total occupant load. The floor area for vehicular drive aisles shall be permitted to be excluded in the determination of net floor area in parking garages.

75

75

CODE CHANGE

2024 IBC Risk Categories

Free standing parking garages not used for the storage of emergency services vehicles, and not providing means of egress for buildings or structures assigned to a higher risk category, shall be assigned to Risk Category II.

- Most parking garages now RC II
- Can exclude drive aisles in net area calcs

76 IBC § 1604.5 Exception 2 & Table 1604.5 footnote "a"

76

CODE CHANGE

2024 IBC Risk Categories

- Power generating stations
  - No IBC definition
  - 75 MW_{AC} established as smallest power-producing unit
  - Risk Category III

77 IBC Table 1604.5

77

CODE CHANGE

2024 IBC Risk Categories

Risk Category	Nature Of Occupancy
IV	Buildings and other structures designated as essential facilities and buildings where loss of function represents a substantial hazard to occupants or users, including but not limited to: • Group I-2 occupancies, ~~Condition 2 occupancies having emergency surgery or emergency treatment facilities.~~ • Group I-3 occupancies other than Condition 1. • Public utility facilities providing power generation, potable water treatment, or wastewater treatment.

Moved from RC III

RC III

78

78

CODE CHANGE

2024 IBC Risk Categories

RC IV

- Essential facilities
- Buildings where loss of function represents a substantial hazard to occupants or users

Institutional Occupancy		RC III	RC IV
I-2	24-hr medical care for 6+ persons incapable of self-preservation		x
I-3	Prisons/jails/detention for 6+ persons		
	Condition 1 – self-preservation capability	x	
	Other than Condition 1		x

79 IBC Table 1604.5

79

CODE CHANGE

2024 IBC Risk Categories

RC IV

- Essential facilities
- Buildings where loss of function represents a substantial hazard to occupants or users
  - Public utility facilities providing power generation, potable water treatment, or wastewater treatment

Credit: www.greshamsmith.com
Public Domain - Wikimedia

80

IBC Table 1604.5

80

CODE CHANGE

2024 IBC Risk Categories

- Photovoltaic (PV) system definitions
- Ground-mounted PV system
  - Independent system without useable space underneath
  - Installed directly on the ground
- Elevated PV system
  - Independent support structure designed with useable space beneath
    - Minimum clear height of 7.5 feet
  - Intended for secondary use
    - e.g. vehicle shade or parking

81

IBC § 202

81

CODE CHANGE

2024 IBC Risk Categories

Photovoltaic (PV) panel Systems

PV Systems & Elevated PV Support		Risk Category (RC)			
		I	II	III	IV
1	Ground mounted for Group R-3 only	x			
2	Ground mounted other than 1 & 5		x		
3	Elevated other than 4, 5 & 6		x		
4	Rooftop and elevated PV on top of buildings	Same as building RC			
5	Paired with ESS & dedicated backup for RC IV building				x
6	Elevated & used for emergency vehicle parking				x

82

IBC § 1604.5.2

82

CODE CHANGE

Importance Factor

Risk Category from Table 1.5-1	~~Snow~~ I_s	~~Ice – Thickness~~ I_i	~~Ice – Wind~~ I_w	Seismic I_e
I	~~0.80~~	~~0.80~~	~~1.00~~	1.00
II	~~1.00~~	~~1.00~~	~~1.00~~	1.00
III	~~1.10~~	~~1.15~~	~~1.00~~	1.25
IV	~~1.20~~	~~1.25~~	~~1.00~~	1.50

- Importance factors eliminated for snow and ice since values are now provided for each risk category
- Seismic system reliabilities are different from those for other environmental hazards

83

ASCE 7-22 Table 1.5-2

83

APPLICATION

7. Risk category descriptions are not the same in the IBC as in ASCE 7. Which governs?

a. IBC
b. ASCE 7
c. Use whichever one you want
d. Flip a coin

[A] 102.4.1 Conflicts. Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

84

84

Summary

1. Load Path – transferring building loads into the earth
2. Load Combinations – accounting for improbability of simultaneous maximum live loads
3. Risk Categories – building classification based on hazard to life for determining load magnitudes
4. IBC 2024 loads' changes consistent with ASCE 7-22

85

85

Resources

Available for use or that can be used for support or help

86

86

STRUCTURE Magazine Articles

code UPDATES

2024 IBC Significant Structural Changes

- Part 5: Structural Design (Ch 16) Risk Categories
- Part 6: Structural Design (Ch 16) Loads

structuremag.org – March & April 2024

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COURSE OUTLINE

- Construction Documents
- Dead Loads
- Live Loads
- Rain Loads

4

4

Construction Documents

Describing project elements to obtain a building permit

11

11

Construction Documents

- Floor live load
  - Live load reductions
- Roof live load
- Special loads
  - Machinery/equipment
  - Greater than floor/roof loads
  - PV panel system dead loads
- Rain load data
  - Intensity
  - Drain, scupper and overflow locations

§ 1603

12

12

Dead Loads

Weight of materials to produce most severe load effect

13

13

Dead Loads

- Weights of
  - Construction materials
    - Walls
    - Floors
    - Roofs
    - Ceilings
  - Fixed service equipment
    - MEP
    - Tanks
  - Photovoltaic panels
  - Vegetative and landscaped roofs

§ 3.1

§ 1606

14

14

Dead Load – PV System

- Photovoltaic panels
  - Panel systems
  - Support system
  - Ballast

§ 3.1.5

§ 1606.4

18

18

Dead Load – Vegetative/Landscaped Roof

- Vegetative and landscaped roofs
  - Landscaping and hardscaping
  - Fully saturated soil
  - Fully dry soil
  - Most severe load effects

§ 3.1.4

§ 1606.5

19

19

APPLICATION

4. Assuming a fully saturated soil will always produce the most severe load effect on a landscaped roof?

a) True

b) False

20

20

Live Loads

Produced by use and occupancy not construction/environmental

21

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Live Loads

CODE CHANGE

§ 1607

Subject	2024 IBC	2021 IBC	Changes
Uniform	1607.3	1607.3	Reorg
Partial Loading of Floors	1607.3.1	1607.13	Reorg
Partial Loading of Roofs	1607.3.2	1607.14	Reorg
Partitions	1607.5	1607.5	Reorg and ASCE 7-22
Helipads	1607.6	1607.6	Reorg and revise
Heavy Vehicle	1607.8	1607.8	Emergency vehicles
Handrails and Guards	1607.9	1607.9	ASCE 7-22
Fixed Ladders	1607.10	1607.17	Renumbered
Vehicle Barriers	1607.11	1607.10	Renumbered
Impact	1607.12	1607.11	Renumbered
Reduction Uniform LL	1607.13	1607.12	Renumbered
Alternate ULL Reduction	1607.13.2	1607.12.2	Reorg

22

22

Live Loads

CODE CHANGE

§ 1607

Subject	2024 IBC	2021 IBC	Changes
Reduction Uniform RLL	1607.14	1607.14.2	Reorg
Occupiable Roofs	1607.14.2	1607.14.2.2	Reorg
Awnings and Canopies	Deleted	1607.14.3	Covered elsewhere
Photovoltaic Systems	1607.14.3	1607.14.4	Reorg
Crane	1607.15	1607.15	ASCE 7-22
Library Stack Rooms	1607.17	1607.18	Renumbered
Assembly Seating	1607.18	1607.19	Renumbered
Sidewalks/Driveways – Trucks	1607.19	1607.20	Renumbered
Stair Treads	1607.20	1607.21	Renumbered
Residential Attics	1607.21	1607.22	Renumbered

23

23

Concentrated vs Uniform Loads

§ 1607.3 & 1607.4

2×10 REQUIRED

12 FEET

2×6 REQUIRED

12 FEET

24

24

CODE CHANGE

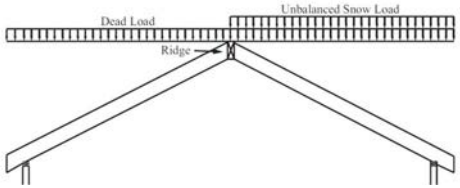
§ 1607.3

25

Uniform Live Loads

The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall not be less than the minimum uniformly distributed live loads given in Table 1607.1. Live loads acting on a sloping surface shall be assumed to act vertically on the horizontal projection of that surface.

- Moved from 1607.14



2018 WFCM Commentary – American Wood Council, Leesburg, VA

25

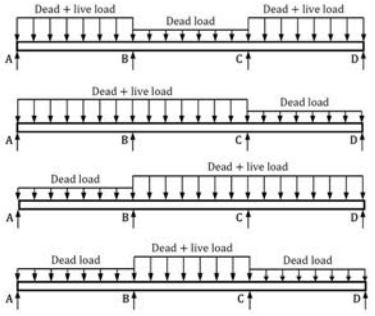
CODE CHANGE

§ 1607.3.1 & 1607.3.2

26

Live Loads – Partial Loading

- Floors and Roofs
  - Moved from 1607.13 and 1607.14 and modified
  - DL + patterned LL
    - Produce greatest load effect
  - Reduced LL permitted



Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

26

CODE CHANGE

T 1607.1

28

Minimum Live Loads

OCCUPANCY OR USE		UNIFORM (psf)	CONCENTRATED (lbs)
15. Garages and vehicle floors	Passenger vehicles ~~only~~ garages	40	See § 1607.7
	Trucks and buses	See § 1607.8	
	Fire trucks and emergency vehicles	See § 1607.8	
	Forklifts and movable equipment	See § 1607.8	
17. Helipads	Helicopter takeoff weight 3,000 lb or less	40	See § 1607.6.1
	Helicopter takeoff weight more than 3,000 lb	60	See § 1607.6.1

- Primarily reformatting

Live Load Reduction not Permitted

28

CODE CHANGE

T 1607.1

29

Minimum Live Loads

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs)
25. Public restrooms	Same as live load for area served but not required to exceed 60 psf	–

- Remaining sections renumbered

29

CODE CHANGE

§ 1607.5

30

Partition Loads

In office buildings and in other buildings where partition locations are subject to change, provisions for partition weight shall be made, whether or not partitions are shown on the construction documents~~, unless the specified *live load* is 80 psf or greater~~. The partition *load* shall be not less than a ~~uniformly distributed~~ *live load* of 15 psf and shall not be reduced per Section 1607.13.

Exception: A partition *live load* is not required where the minimum specified *live load* is 80 psf or greater.

- Consistent with ASCE 7-22 § 4.3.2
- Partition live loads are not reducible
  - Can be relocated and clustered differently

30

CODE CHANGE

§ 1607.8.2

31

Fire Trucks and Emergency Vehicles

Emergency vehicle loads need not be assumed to act concurrently with other uniform live loads.

- Consistent with ASCE 7-22 new section §4.10.4
- Operating loads
- Wheel and outrigger reactions
  - Outriggers up to 60,000 lb

https://www.chicagotribune.com/news/breaking/ct-fire-engine-fall-after-parking-garage-collapsed-20190806-bt42ai7z2jhjzcjrtrwe7vrsb4-story.html

31

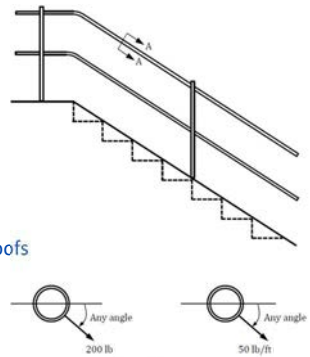
CODE CHANGE

§ 1607.9

33

Handrails and Guards

- Consistent with ASCE 7-22 § 4.5
- 50 plf uniform load
  - Not concurrent with 200 lb concentrated load
  - Does not apply to unoccupiable roofs



Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

33

APPLICATION

38

5. For handrails and guards, the 50 plf uniform load is assumed to act concurrently with the 200 lb concentrated load?

a. True
b. False

38

Rain Loads

Rainfall rates are now based on building risk category

39

39

Rain Loads

- Intensity based on 15-min duration storms for secondary drains
- Return period based on Risk Category
- Ponding provisions updated consistent with ASCE 7-22

§ 1611

40

40

CODE CHANGE

Design Rain Load

Each portion of a roof shall be designed to sustain the load of rainwater as per the requirements of Chapter 8 of ASCE 7. Rain loads shall be based on the summation of the static head, d_s, hydraulic head, d_h, and ponding head, d_p, using Equation 16-19. The hydraulic head shall be based on hydraulic test data or hydraulic calculations assuming a flow rate corresponding to a rainfall intensity equal to or greater than the 15-minute duration storm with return period given in Table 1611.1. Rainfall intensity shall be determined in inches per hour for 15-minute duration storms for Risk Category given in Table 1611.1. ~~The design rainfall shall be based on the 100-year 15-minute duration event, or on other rainfall rates determined from approved local weather data. Alternatively, a design rainfall of twice the 100-year hourly rainfall rate indicated in Figures 1611.1(1) through 1611.1(5) shall be permitted.~~ The ponding head shall be based on structural analysis as the depth of water due to deflections of the roof subjected to unfactored rain load and unfactored dead load.

- Consistent with ASCE 7-22 § 8.2
  - Ponding head added
- Primary drain typically designed for 1-hour duration
- Secondary drain must be designed for 15-minute duration
  - Option for 2x hourly rate deleted

§ 1611.1

41

41

Design Process for Rain Loads

Step	Procedure
1	Determine the rainfall intensity, i, for the Risk Category given in IBC Table 1611.1
2	Determine the flow rate, Q
3	Obtain the static head, d_s
4	Determine the hydraulic head, d_h
5	Determine the ponding head, d_p
6	Determine the design rain load, R

Adapted from *Structural Load Determination: 2024 IBC and ASCE/SEI 7-22* – McGraw Hill

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42

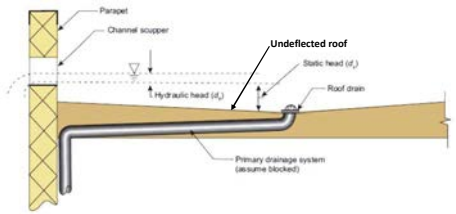
CODE CHANGE

§ 1611.1

Rain Loads

$R = 5.2(d_s + d_h + d_p)$ (IBC Equation 16-20)

R – rain load on undeflected roof
d_s – static head
d_h – hydraulic head
d_p – ponding head



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43

CODE CHANGE

§ 1611.1

Rain Loads

- Secondary drainage system for structural loading (SDSL)
  - Roof drainage system through which water is drained when primary drainage system blocked
  - SDSL ≥ 2" above primary drain

44

44

CODE CHANGE

§ 1611.1

Rain Loads

IBC Table 1611.1 Design Storm Return Period by Risk Category

Risk Category	Design Storm Return Period
I & II	100 years
III	200 years
IV	500 years

- Existing IBC rainfall maps deleted
- Intensity based on risk category
- ASCE Hazard Tool
  - Free resource for determining rain load
  - 15-min and 60-min intensities

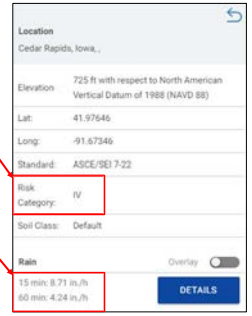
45

45

EXAMPLE

Rain Load

- Cedar Rapids, IA
- Risk Category IV building
- 5,000 ft² tributary area
  - Primary
    - 4.24 in/hr (60 min, 500-yr)
  - Secondary
    - 8.71 in/hr (15 min, 500-yr)
- Calculate primary and secondary drain size and resulting rain load, R



asce7hazardtool.online

48

48

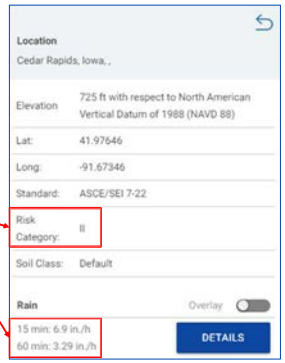
EXAMPLE

T 1611.1

Rain Loads – Risk Category Comparison

Cedar Rapids, IA Example

Risk Category	Rate (in/hr)	
	15-min	60-min
I & II	6.90	3.29
III	7.66	3.69
IV	8.71	4.24



asce7hazardtool.online

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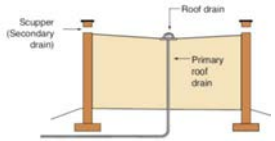
EXAMPLE

§ C8.2

Rain Load – Primary Drain

- Q = 0.0104 x A x i (ASCE 7-22 Eq C8.2-1*)
- where:
  - Q = flow rate for drainage > rainfall rate
  - A = tributary area = 5,000 ft^2
  - i = water depth = 4.24 in/hr (60 min, 500-yr)



- Q = 0.0104 x 5,000 ft^2 x 4.24 in/hr = 221 gal/min

*0.0104 factor converts area (ft^2) and rainfall rate (in/hr) to gal/min

50

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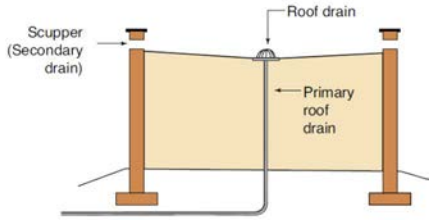
EXAMPLE

§ 1106.2

Rain Load – Primary Drain

- IPC Table 1106.2
- 5” vertical pipe or
- 6” horizontal drain
  - 1/16” per foot min. slope



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EXAMPLE

§ 1106.2

Rain Load – Primary Drain

Primary Q = 221 gal/min

IPC TABLE 1106.2
STORM DRAIN PIPE SIZING

PIPE SIZE (inches)	CAPACITY (gpm)				
	VERTICAL DRAIN	SLOPE OF HORIZONTAL DRAIN			
		1/16 inch per foot	1/8 inch per foot	1/4 inch per foot	1/2 inch per foot
2	34	15	22	31	44
3	87	39	55	79	111
4	180	81	115	163	231
5	311	117	165	234	331
6	538	243	344	487	689
8	1,117	505	714	1,010	1,429
10	2,050	927	1,311	1,855	2,623
12	3,272	1,480	2,093	2,960	4,187
15	5,543	2,508	3,546	5,016	7,093

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52

EXAMPLE

§ C8.2

Rain Load – Secondary Drain

- Q = 0.0104 x A x i (ASCE 7-22 Eq C8.2-1*)
- where:
  - Q = flow rate for drainage > rainfall rate
  - A = tributary area = 5,000 ft²
  - i = 8.71 in/hr (15 min, 500-yr)

- Q = 0.0104 (5,000 ft²) (8.71 in/hr) = 453 gal/min

*0.0104 factor converts area (ft²) and rainfall rate (in/hr) to gal/min

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EXAMPLE

§ C1611.1

Rain Load – Secondary Drain

Secondary Q = 453 gal/min

d_h (hydraulic head) = 4 inches

DRAINAGE SYSTEM	FLOW RATE (gpm) Depth of water above drain inlet (hydraulic head) (inches)							
	1	2	2.5	3	3.5	4	4.5	5
4-inch-diameter drain	80	170	180					
6-inch-diameter drain	100	190	270	380	540			
8-inch-diameter drain	125	230	340	560	850	1,100	1,170	
6-inch-wide, open-top scupper	18	50	*	90	*	140	**	194
24-inch-wide, open-top scupper	72	200	*	360	*	560	*	776
6-inch-wide, 4-inch-high, closed-top scupper	18	50	*	90	*	140	*	177
24-inch-wide, 4-inch-high, closed-top scupper	72	200	*	360	*	560	*	708
6-inch-wide, 6-inch-high, closed-top scupper	18	50	*	90	*	140	*	194
24-inch-wide, 6-inch-high, closed-top scupper	72	200	*	360	*	560	*	776

2021 IBC Commentary Figure 1611.1(2))

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EXAMPLE

§ C1611.1

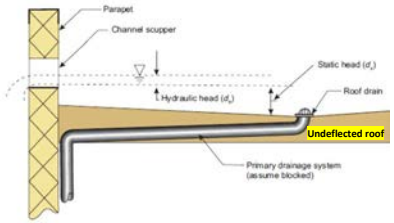
Rain Load – Secondary Drain

- d_s (static head) = 3"
  - specified distance from roof surface to bottom of scupper ≥ 2"

- R = 5.2(d_s + d_h) (IBC Eq 16-19*)
- R = 5.2(3" + 4") = 36.4 psf

*Water density (62.5 pcf)/(12 in/ft)
= 5.2 psf/inch of water depth

Are we done?



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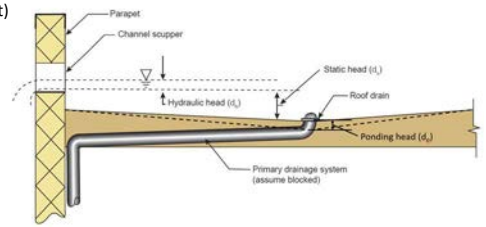
EXAMPLE

§ C1611.1

Rain Load – Secondary Drain

- d_p (ponding head) = 1" (iterative analysis)
  - Water depth due to roof deflections with unfactored rain load, R, and unfactored dead load, D
- R = 5.2(d_s + d_h + d_p) (IBC Eq 16-19*)
- R = 5.2(3" + 4" + 1") = **41.6 psf**

*Water density (62.5 pcf)/(12 in/ft)
= 5.2 psf/inch of water depth



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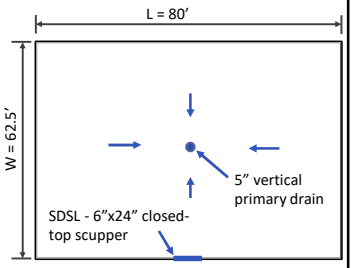
56

EXAMPLE

Rain Loads Supplemental Data Request

References*	Secondary Drain (SDSL) Parameters	Data
IBC 1604.5	Building Risk Category: I, II, III, IV	IV
ASCE 7 C8.2-1	Tributary area, A (ft²)	5,000
asce7hazardtool.online	15-min rainfall intensity, i (in./hr)	8.71
ASCE 7 C8.2-1	Flow rate, Q (gpm)	453
IBC 1611.1	Static head, d_s (in.)	3
IBC 1611.1 Commentary	Hydraulic head, d_h (in.)	4
Per design	Ponding head, d_p (in.)	1
IBC 1611.1	Design rain load, R (psf)	41.6

*IBC 2024 and ASCE 7-22



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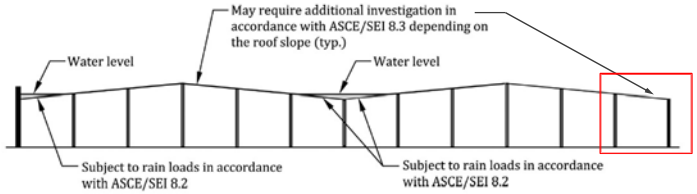
CODE CHANGE

§ 1611.2

Ponding Instability

~~*Susceptible bays* of roofs shall be evaluated for ponding instability in accordance with Chapters 7 and 8 of ASCE 7.~~ Ponding instability on roofs shall be evaluated in accordance with ASCE 7.



58

Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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CODE CHANGE

§ 8.3

Ponding Instability

Free-draining bays and internal bays not subjected to accumulated rain load required by Section 8.2 shall have adequate strength and stiffness to preclude progressive deflection (i.e., instability) and resist potential ponding rain loads where either of the following conditions are met:

1. The roof slope is less than 1/4 in. per foot (1.19 degrees), or
2. The bay is adjacent to a free-draining edge with secondary members parallel to the free-draining edge and the roof slope is less than β where $\beta = (L_s/S + \pi)/20$ (in. per foot).

59

Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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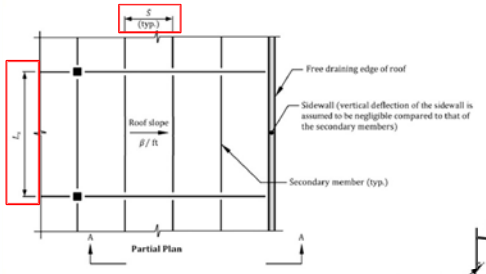
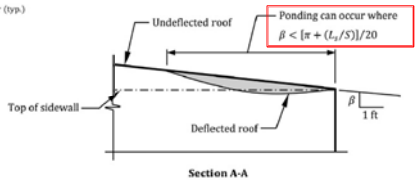
CODE CHANGE

Eq C8.3-2

Ponding Instability – Secondary Members ‖



L_s = secondary member span
S = secondary member spacing
β = specified roof slope



60

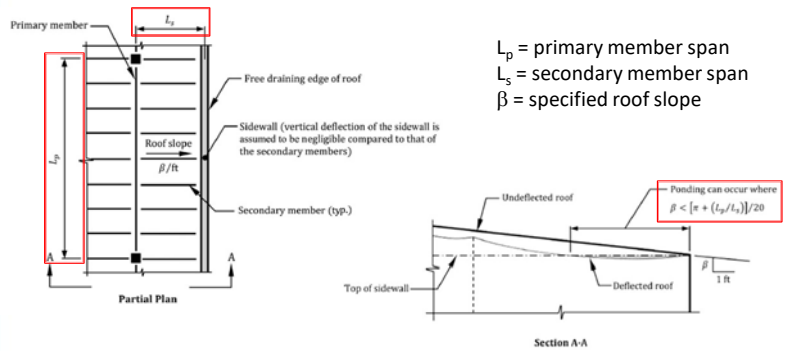
Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

60

CODE CHANGE

Eq C8.3-1

Ponding Instability – Secondary Members ⊥



L_p = primary member span
L_s = secondary member span
β = specified roof slope

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EXAMPLE

Ponding Instability

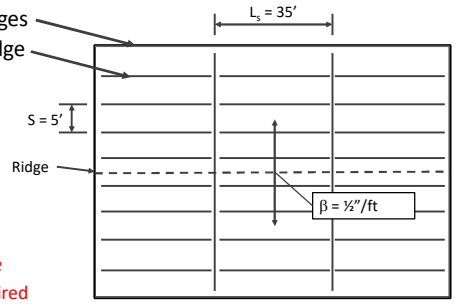
- Is roof susceptible to ponding?
- Assume free-draining edges
- Secondary members ‖ edge
- β = 0.5”/ft
- L_s = 35’
- S = 5’

$$\frac{1}{20}\left(\pi + \frac{L_s}{S}\right)$$

= (3.14 + 35/5)/20 = 0.51”

0.51” > 0.5” → susceptible

- Additional investigation required



63

EXAMPLE

Ponding Instability Supplemental Data Request

Reference*	Ponding Instability Parameters (IBC 1611.2)	Data
ASCE 7 § 8.3	Roof slope < ¼” per foot? If yes, additional investigation required	No
ASCE 7 Eq C8.3-2	Secondary members parallel to free-draining edge?	
	Secondary member span, L_s (ft)	35
	Secondary member spacing, S (ft)	5
	Specified slope, β (in./ft)	0.50
	Calculated slope comparison (in./ft)	0.51
	If β < calculated value, then additional investigation required	Yes
ASCE 7 Eq C8.3-1	Secondary members perpendicular to free-draining edge?	
	Secondary member span, L_s (ft)	
	Primary member span, L_p (ft)	
	Specified slope, β (in./ft)	
	Calculated slope comparison (in./ft)	
	If β < calculated value, then additional investigation required	

*IBC 2024 and ASCE 7-22

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APPLICATION

6. Rainfall intensity for a secondary drain system is based on which of the following durations?

a) 15-minute
b) 30-minute
c) 45-minute
d) 60-minute

65

Summary

1. Dead Loads – weight of materials to produce most severe load effect
2. Live Loads – produced by use and occupancy not construction or environmental (significant reorg)
3. Rain Loads – rainfall rates are now based on building risk category and new ponding instability provisions in ASCE 7-22
4. IBC 2024 loads' changes consistent with ASCE 7-22

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Resources

Available for use or that can be used for support or help

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IBC Plan Review Record

2021 INTERNATIONAL BUILDING CODE® PLAN REVIEW RECORD

JURISDICTION

BUILDING LOCATION

BUILDING DESCRIPTION

REVIEWED BY:

CORRECTIONS LIST

No.	DESCRIPTION	Code Section

STRUCTURAL DESIGN (Chapter 16)

STRUCTURAL DESIGN CALCULATIONS

Submitted for all structural members (106, 107.1, 107.2.1, 1604, 1605)

DESIGN LOADS ON CONSTRUCTION DOCUMENTS (107.2.7, 1603)

Uniformly distributed floor live loads (1603.1.1, Table 1607.1)

Floor Area Use | Loads Shown

Live load reduction (1603.1.1, 1607.12, 1607.13)

Roof live loads (1603.1.2, 1607.14)

Rain intensity, i (1603.1.3)

DESIGN LOADS (continued)

Wind loads (1603.1.4, 1609; Chapters 26 - 31 of ASCE 7)

Design procedure (1609.1.1; Chapters 26 - 31 of ASCE 7)

Wind speed (1609.3; Figs. 26.5-1, 26.5-2 of ASCE 7)

Risk category (Table 1604.5; Table 1.5-1 of ASCE 7)

Surface roughness/Exposure categories (1609.4; 26.7 of ASCE 7)

Internal pressure coefficient (26.13, Table 26.13-1 of ASCE 7)

Component and cladding pressures (Chapter 30 of ASCE 7)

Main wind-force resisting system (1609.5; 27.3 - 27.5, 28.3 - 28.5 of ASCE 7)

Roof snow loads (1603.1.5, 1608; Chapter 7 of ASCE 7)

Ground snow load, p_g (1608.2; 7.2 of ASCE 7)

If p_g > 10 psf, flat-roof snow load, p_f (7.3 of ASCE 7)

If p_g > 10 psf, snow exposure factor, C_e (Table 7.3-1 of ASCE 7)

If p_g > 10 psf, snow load importance factor, I_s (7.3.3, Table 1.5-2 of ASCE 7)

If p_g > 10 psf, roof thermal factor, C_t (Table 7.3-2 of ASCE 7)

If p_g > 10 psf, slope factor(s), C_s (7.4 of ASCE 7)

If p_g > 10 psf, drift surcharge loads, p_d, (l, h_d, w of ASCE 7)

If p_g > 10 psf, width of snow drift, w (7.7, 7.8 of ASCE 7)

Ponding instability (1608.2; 7.11, 8.4 of ASCE 7)

Site class (1613.2.2; 11.4.3, Chapter 20 of ASCE 7)

Seismic design category (1613.2.5; 11.6 of ASCE 7)

Basic seismic-force-resisting system (Table 12.2-1 of ASCE 7)

Response modification coefficient, R (Table 12.2-1 of ASCE 7)

Seismic response coefficient, C_s (12.8.1.1 of ASCE 7)

Analysis procedure (12.6 of ASCE 7)

Design base shear (12.8.1 of ASCE 7)

Flood loads (1603.1.7, 1612)

Flood hazard area (1612.3)

Documentation (1612.4)

Ice loads (1614; Chapter 10 of ASCE 7)

Compliance

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COURSE OUTLINE

- Snow Loads
  - Definitions and Notations
  - Construction Documents
  - Deflection Limits
  - Load Combinations
  - Design Provisions
  - Example
- Atmospheric Ice Loads
  - Load Combinations
  - Definitions and Symbols
  - Design Provisions
  - Example
- Resources

4

4

Snow Loads

Ground snow loads are now based on risk category

11

11

CODE CHANGE

§ 202

Definitions

GROUND SNOW LOAD GEODATABASE. The ASCE database (version 2022-1.0) of geocoded values of risk-targeted design ground snow load values.

GROUND SNOW LOAD, p_g. Design ground snow loads.

GROUND SNOW LOAD, $p_{g(asd)}$. Allowable stress design ground snow loads.

- Added for consistency with ASCE 7-22
- Design GSL is strength-based
- Conversion to ASD GSL as needed

12

12

CODE CHANGE

§ 1602

Notations

$p_{g(asd)}$ = Allowable stress design ground snow load.

p_g = Ground snow load determined from Figures 1608.2(1) through 1608.2(4) and Table 1608.2.

- Added for consistency with ASCE 7-22
- Strength-based vs ASD ground snow load values

13

13

CODE CHANGE

§ 1603.1

Construction Documents – General

Exception: Construction documents for buildings constructed in accordance with the conventional light-frame construction provisions of Section 2308 shall indicate the following structural design information:

1. Floor and roof dead and live loads.
2. Ground snow load, p_g, and allowable stress design ground snow load, $p_{g(asd)}$.

- Added for IBC provisions still relying on ASD values
- Conversion equation given in IBC
- ASCE Hazard tool also provides ASD values (asce7hazardtool.online)
  - Free resource

14

14

CODE CHANGE

§ 1603.1.3

Construction Documents – Roof Snow Load Data

Roof snow load data. The ground snow load, p_g, shall be indicated. In areas where the ground snow load, p_g, exceeds ~~10~~ 15 pounds per square foot (psf), the following additional information shall also be provided, regardless of whether snow loads govern the design of the roof:

1. Flat-roof snow load, p_f.
2. Snow exposure factor, C_e.
3. ~~Snow load importance factor, I_s.~~ Risk category.
4. Thermal factor, C_t.
5. Slope factor(s), C_s.
6. Drift surcharge load(s), p_d, where the sum of p_d and p_f exceeds ~~20~~ 30 psf.
7. Width of snow drift(s), w.
8. Winter wind parameter for snow drift, W_2.

- Modified for consistency with ASCE 7-22
- Values vary based on risk category

15

15

CODE CHANGE

T 1604.3

Deflection Limits

TABLE 1604.3—DEFLECTION LIMITS[a, b, c, h, i]

CONSTRUCTION	L or L_r	S[j] or W[f]	D + L[d, g]
Roof members:[e]			
Supporting plaster or stucco ceiling	l/360	l/360	l/240
Supporting nonplaster ceiling	l/240	l/240	l/180
Not supporting ceiling	l/180	l/180	l/120

j. The snow load shall be permitted to be taken as 0.7 times the design snow load determined in accordance with Section 1608.1 for the purpose of determining deflection limits in Table 1604.3.

- New footnote
- Reduces strength-based snow loads to ASD levels

16

16

CODE CHANGE

§ 1605.1

Load Combinations – LRFD/Strength Design (SD)

1.2D + 1.6L + (0.5L_r or 0.3S or 0.5R) (Eq 2a)

1.2D + (1.6L_r or 1.0S or 1.6R) + (L or 0.5W) (Eq 3a)

1.2D + 1.0(W or W_T) + L + (0.5L_r or 0.3S or 0.5R) (Eq 4a)

1.2D + E_v + E_h + L + 0.15S (Eq 6)

ASCE 7 § 2.3

17

17

CODE CHANGE

§ 1605.1

Load Combinations – ASD

D + (L_r or 0.7S or R) (Eq 3a)

D + 0.75L + 0.75(L_r or 0.7S or R) (Eq 4a)

D + 0.75L + 0.75(0.6(W or W_T)) + 0.75(L_r or 0.7S or R) (Eq 6a)

D + 0.525E_v + 0.525E_h + 0.75L + 0.1S (Eq 9)

Exceptions:

2. Where the allowable stress design load combinations of ASCE 7 Section 2.4 are used, flat roof snow *loads* of ~~30~~ 45 pounds per square foot or less and *roof live loads* of 30 pounds per square foot or less need not be combined with seismic loads. Where flat roof snow loads exceed ~~30~~ 45 pounds per square foot, ~~20~~ 15 percent shall be combined with seismic loads.

ASCE 7 § 2.4

18

18

CODE CHANGE

§ 1605.2

Load Combinations – Alternative ASD

D + L + (L_r or 0.7S or R) (Eq 16-1)

D + L + 0.6W + 0.7S/2 (Eq 16-3)

D + L + 0.7S + 0.6W/2 (Eq 16-4)

D + L + 0.7S + E/1.4 (Eq 16-5)

Exceptions:

2. Flat roof snow *loads* of ~~30~~ 45 pounds per square foot or less and *roof live loads* of 30 pounds per square foot or less need not be combined with seismic loads. Where flat roof snow loads exceed ~~30~~ 45 pounds per square foot, ~~20~~ 15 percent shall be combined with seismic loads.

19

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CODE CHANGE

§ 1608.1

Snow Loads – General

Design snow loads shall be determined in accordance with Chapter 7 of ASCE 7, but the design roof load shall be not less than that determined by Section 1607.

Exception: Temporary structures complying with Section 3103.6.1.1.

- Significant changes to loading provisions for temporary structures
  - Reduced ground snow load based on
    - Service life
    - Risk category

20

20

CODE CHANGE

§ 1608.2

Ground Snow Loads

The ground snow *loads* to be used in determining the design snow *loads* for roofs shall be determined in accordance with the reliability-targeted (strength based) ground snow load values in Chapter 7 of ASCE 7 or Figures 1608.2(1) ~~and 1608.2(2)~~ through 1608.2(4) for the contiguous United States and Table 1608.2 for Alaska. Site-specific case studies shall be determined in accordance with Chapter 7 of ASCE 7 and shall be *approved* by the *building official*. ~~made in areas designated "CS" in Figures 1608.2(1) and 1608.2(2). Ground snow *loads* for sites at elevations above the limits indicated in Figures 1608.2(1) and 1608.2(2) and for all sites within the CS areas shall be *approved*. Ground snow *load* determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2-percent annual probability of being exceeded (50-year mean recurrence interval).~~ Snow loads are zero for Hawaii, except in mountainous regions as *approved* by the *building official*.

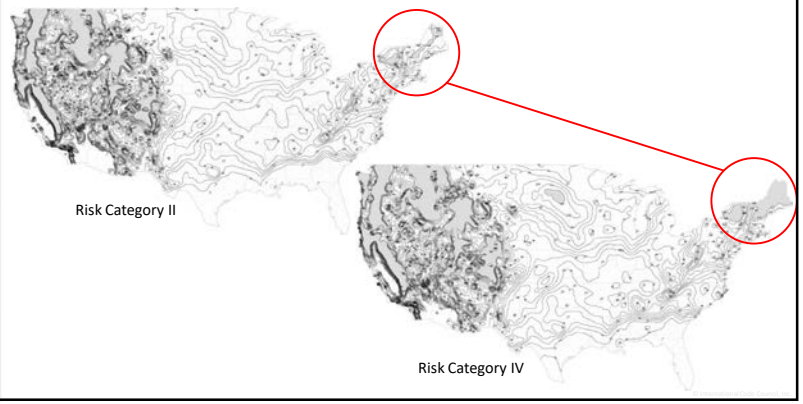
- Strength-based ground snow loads
- New maps based on risk category
- ASCE Hazard tool also provides GSL values (asce7hazardtool.online)
  - Based on risk category
  - Free resource

22

22

CODE CHANGE

Ground Snow Load Maps – Figs 1608.2(2&4)



23

23

CODE CHANGE

Ground Snow Conversion

Where required, the ground snow loads, p_g, of Figures 1608.2(1) through 1608.2(4) and Table 1608.2 shall be converted to allowable stress design ground snow loads, $p_{g(asd)}$, using Equation 16-17.

$$p_{g(asd)} = 0.7\, p_g \qquad \text{(Equation 16-17)}$$

where:

$p_{g(asd)}$ = Allowable stress design ground snow load.

p_g = Ground snow load determined from Figures 1608.2(1) through 1608.2(4) and Table 1608.2.

§ 1608.2.1

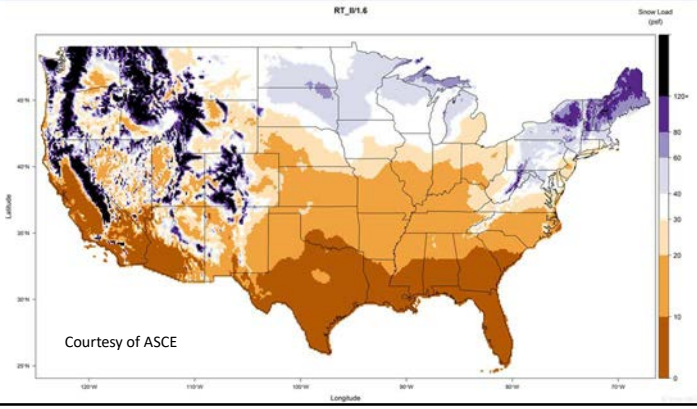
- ASCE Hazard tool also provides ASD values (asce7hazardtool.online)
  - Free resource

24

24

EXAMPLE

Ground Snow Loads – ASD RC II

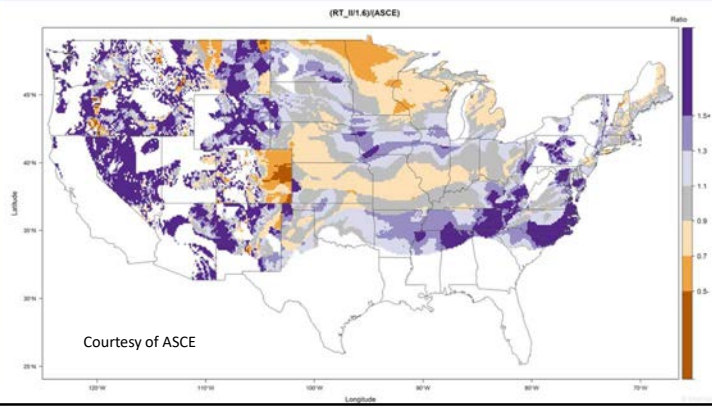


25

25

EXAMPLE

GSL Comparison – IRC 2024/2021



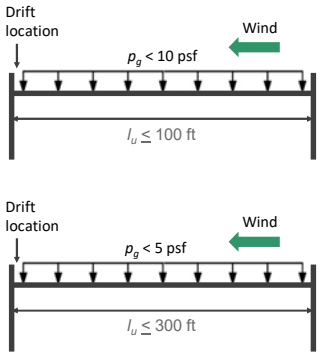
26

26

CODE CHANGE

Snow Load Provisions NOT Required

- No drift potential
- No unbalanced snow loading
- p_g < unfactored L_r
- p_g & l_u relative to drift location
  - As shown graphically →



§ 7.2

27

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APPLICATION

4. Ground snow load determination is based on the risk category of the building?

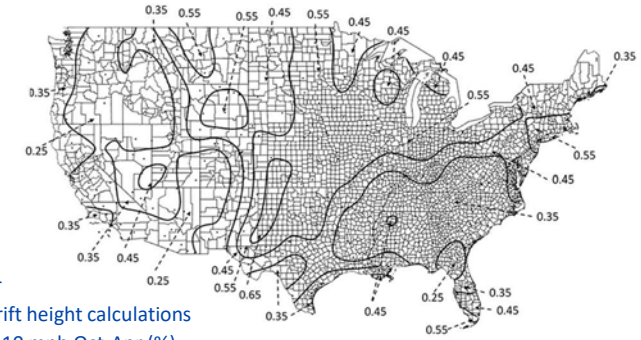
a) True
b) False

28

28

CODE CHANGE

Winter Wind Parameter, W_2



- New factor
- Used for drift height calculations
- Where V > 10 mph Oct-Apr (%)
- Hazard tool also provides values

ASCE 7-22 Figure 7.6-1

§ 7.6.1

29

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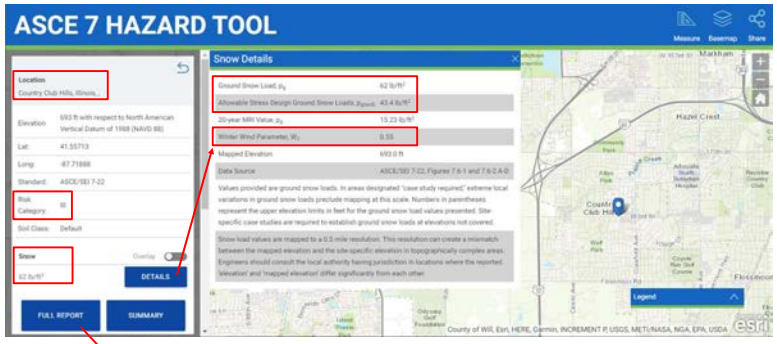
EXAMPLE

asce7hazardtool.online



30

30

EXAMPLE

asce7hazardtool.online

Full Report PDF

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CODE CHANGE

§ 1608.3

Ponding Instability

~~*Susceptible bays* of roofs shall be evaluated for ponding instability in accordance with Chapters 7 and 8 of ASCE 7.~~ Ponding instability on roofs shall be evaluated in accordance with ASCE 7.

- Roofs are subject to ponding due to
  - Primary drains blocked by ice or otherwise
  - Snow melt
  - Rain surcharge

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Design Process for Snow Loads

Step	Procedure
1	Determine ground snow load, p_g, for the site
2	Determine a flat roof snow load, p_f, considering roof exposure and roof thermal condition
3	Determine minimum snow load for low-slope roofs, p_m
4	Determine sloped roof snow load, p_s
5	Consider partial snow loading, where applicable
6	Consider unbalanced roof snow loads, where applicable
7	Consider snow drifts on lower roofs, where applicable
8	Consider snow drifts adjacent to roof projections and parapets, where applicable
9	Consider sliding snow, where applicable
10	Consider rain-on-snow surcharge load, where applicable
11	Consider ponding loads, where applicable
12	Consider snow loads on existing roofs, where applicable
13	Consider snow loads on open-frame equipment structures, where applicable

Adapted from *Structural Load Determination: 2024 IBC and ASCE/SEI 7-22* – McGraw Hill

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CODE CHANGE

Eq. 7.3-1

Flat Roof Snow Loads

- $p_f = 0.7 C_e C_t ~~I_s~~ p_g$
  - p_g = ground snow load, psf
  - 0.7 = basic exposure factor
  - C_e = exposure factor
  - C_t = thermal factor
  - ~~I_s = importance factor for snow~~
    - Removed – since new maps based on risk category

Risk Category III

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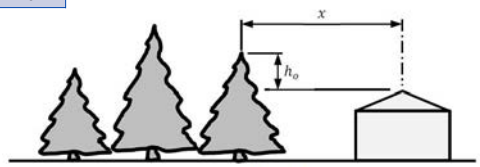
Exposure Factor, C_e

Surface Roughness Category	Exposure of Roof		
	Fully Exposed	Partially Exposed	Sheltered
B	0.9	1.0	1.2
C	0.9	1.0	1.1
D	0.8	0.9	1.0

ASCE 7-22 Excerpt of Table 7.3-1



Obstruction provides shelter where $x \leq 10h_o$

§ 7.3.1

Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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Thermal Factor, C_t

CODE CHANGE

Thermal Condition	C_t
Unheated, open-air, cold ventilated roofs	1.2
Freezer building	1.3
Greenhouses	0.85

ASCE 7-22 Excerpt of Table 7.3-2

New Table

C_t for Heated Structures with Unventilated Roofs

R_{roof}	p_g (psf)						
	≤10	20	30	40	50	60	≥70
≤20	1.20	1.11	1.05	1.01	1.00	1.00	1.00
30	1.20	1.17	1.14	1.13	1.12	1.11	1.10
40	1.20	1.19	1.17	1.16	1.16	1.15	1.15
50	1.20	1.20	1.19	1.19	1.19	1.18	1.18

$U_{roof} = 1 / R_{roof}$

$R_{roof} > 50 \rightarrow C_t = 1.2$

ASCE 7-22 Excerpt of New Table 7.3-3

§ 7.3.2

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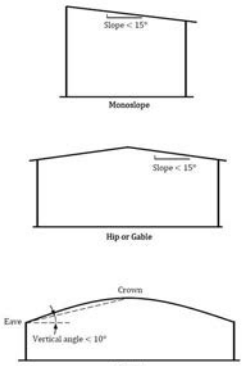
Minimum Snow Loads – Low-sloped Roofs

CODE CHANGE

Risk Category	$p_{m,max}$ (psf)
I	25
II	30
III	35
IV	40



$p_g \leq p_{m,\max} \rightarrow p_m = p_g$

$p_g > p_{m,\max} \rightarrow p_m = p_{m,\max}$

Figure 4.2 from *Structural Load Determination: 2024 IBC and ASCE/SEI 7-22* – McGraw Hill

§ 7.3.3

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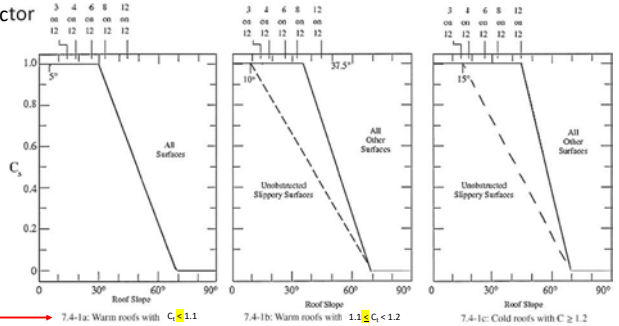
Sloped Roof (balanced) Snow Loads, p_s

CODE CHANGE

$p_s = C_s p_f$

C_s = slope factor



Revised Ranges

ASCE 7-22 Figure 7.4-1

Eq 7.4-1 & F 7.4-1

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Roof Surface Friction

Slippery roof surfaces	Metal
	Slate
	Glass
	Bituminous membranes*
	Rubber membranes*
	Plastic membranes*
Not slippery roof surfaces	Asphalt shingles
	Wood shingles
	Shakes

*Slippery = smooth. Membranes with embedded aggregate or mineral granule surface ≠ smooth.

§ 7.4

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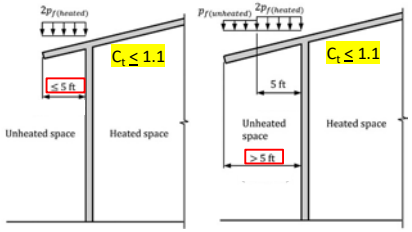
Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

40

Ice Dams at Eaves

CODE CHANGE

§ 7.4.4 & F C7.4-1



C_t for Heated Structures with Unventilated Roofs

R_{roof}	p_g (psf)						
	≤10	20	30	40	50	60	≥70
≤20	1.20	1.11	1.05	1.01	1.00	1.00	1.00
30	1.20	1.17	1.14	1.13	1.12	1.11	1.10
40	1.20	1.19	1.17	1.16	1.16	1.15	1.15
50	1.20	1.20	1.19	1.19	1.19	1.18	1.18

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Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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Unbalanced Loading – All Other Gable Roofs

CODE CHANGE

§ 7.6 & Eq 7.6-1

h_d = drift height

Revised

$$h_d = 1.5\sqrt{\frac{(p_g)^{0.74}(\ell_u)^{0.70}(W_2)^{1.7}}{\gamma}}$$

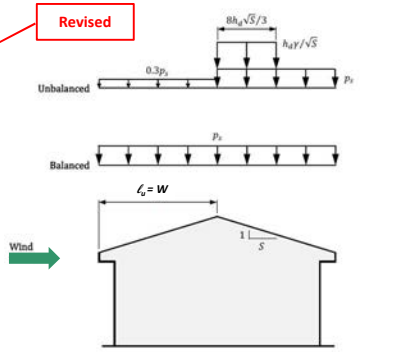
ℓ_u = W

$W \neq W_2$

W_2= winter wind parameter

γ = snow density

= $0.13p_g + 14 \leq 30$ lb/ft^3



45

Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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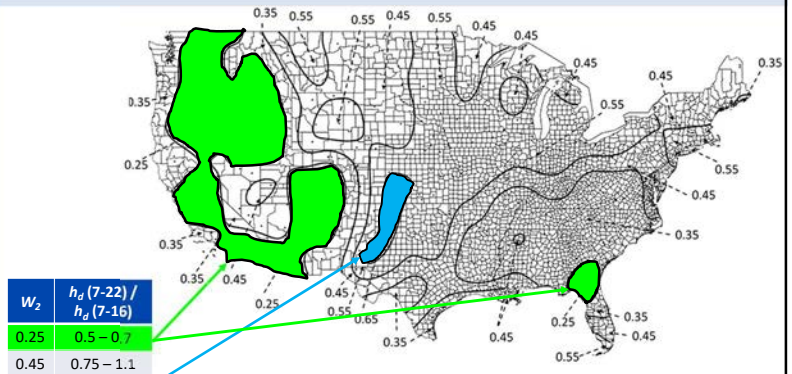
Drift Height (h_d) Comparison Based on W_2

CODE CHANGE

§ 7.6 & Eq 7.6-1



W_2	h_d (7-22) / h_d (7-16)
0.25	0.5 – 0.7
0.45	0.75 – 1.1
0.65	1.0 – 1.5

Stats: Snow and Rain Loads in ASCE 7-22 – Part 1, *Structure Magazine*, O'Rourke and Duntemann, Jan 2022

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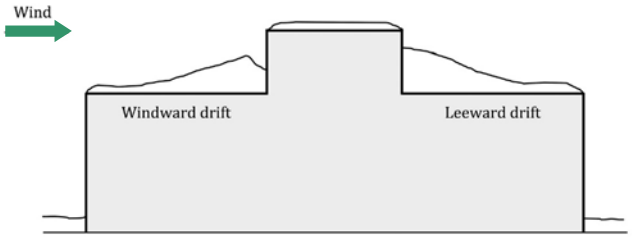
CODE CHANGE

Drifts on Lower Roofs

- Windward and leeward drift loads analyzed separately
  - Determine which controls supporting member design
  - Higher drift height no longer governs



§ 7.7.1

47

Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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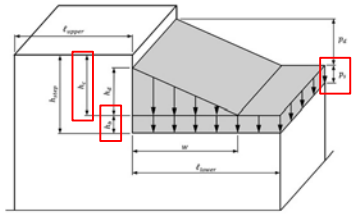
CODE CHANGE

Drifts – Windward or Leeward

Drift loads need not be considered where $h_c / h_b < 0.2$

- $h_b = p_s /$ density (γ)



Depth (in.)		
h_b	h_c	h_{step}
12	2.4	14.4
24	4.8	28.8
36	7.2	43.2

§ 7.7.1

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Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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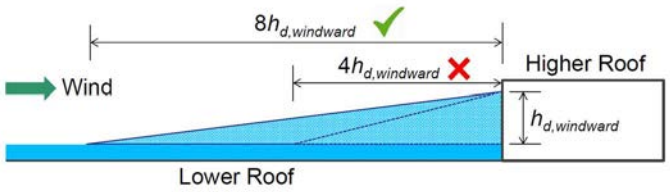
CODE CHANGE

Windward Drift Length



§ 7.7.1

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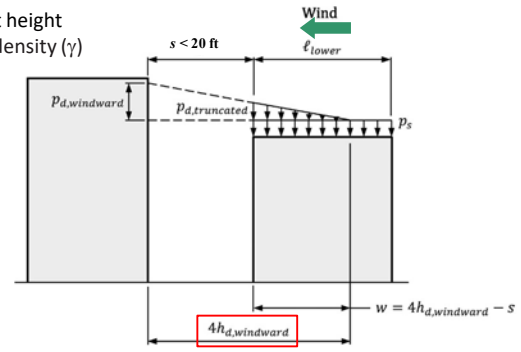
Windward Drifts – Adjacent Roofs

h_d = drift height
$p_d = h_d$ x density (γ)



§ 7.7.1

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Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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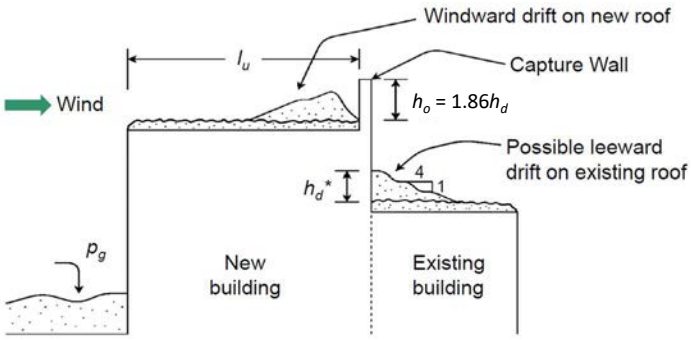
Leeward Drifts – Capture Walls



Adapted from ASCE 7-22 Commentary Figure C7.7-2

F C7.7-2

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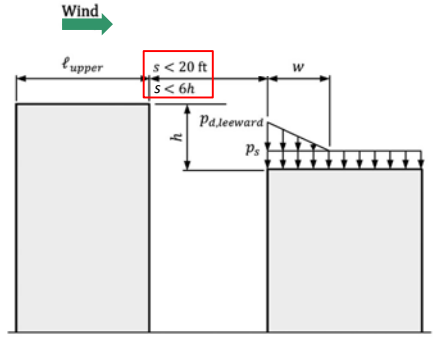
Leeward Drifts – Adjacent Roofs



Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

§ 7.7.2

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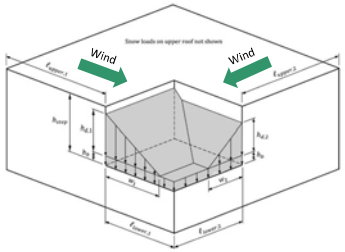
CODE CHANGE

Intersecting Drifts – Lower Roofs

- Evaluated at
  - Reentrant corners
  - Parapet wall corners
  - Gable roof and roof step wall
- Larger of 2 drift depths govern
- Not superimposed



Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

§ 7.7.3

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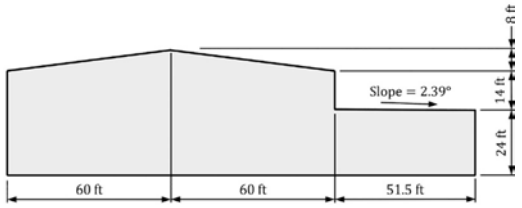
EXAMPLE

Design Snow Loads

- Location: Fort Collins, CO
- Surface Roughness: B
  - Sheltered Roof Exposure
- Risk Category: II
- Heated structure
  - Unventilated roof
  - R = 50
- Metal roof



Ex 4.7

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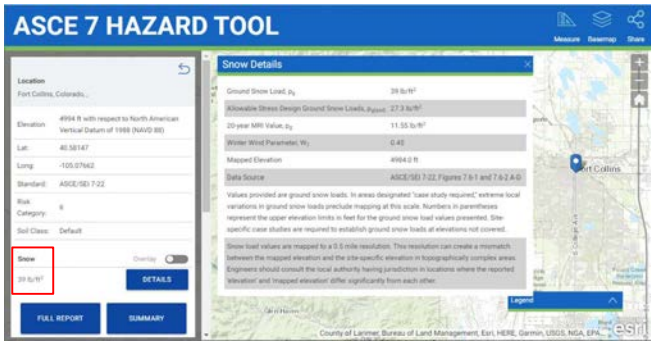
EXAMPLE

Snow Load Supplemental Data Request



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EXAMPLE

Snow Load Supplemental Data Request

References*	Snow Load Parameters (IBC 1608.1)	Data
IBC 1604.5	Building Risk Category: I, II, III, IV	II
IBC 1608.2	Ground snow load, p_g (psf)	39.0
ASCE 7 §7.3.1	Roof exposure factor, C_e: B, C, D and Roof Exposure	1.2
ASCE 7 §7.3.2	Roof thermal condition, C_t	1.19
ASCE 7 §7.3	Flat roof snow load, p_f (psf)	39.0
ASCE 7 §7.3.3	Minimum snow load for low-slope roofs, p_m (psf)	30.0
ASCE 7 §7.4	Sloped roof snow load, p_s (psf)	39.0
ASCE 7 §7.5	Partial snow loading: gable roof slope < ½ /12	n/a
ASCE 7 §7.6	Unbalanced roof snow loads (psf): windward, leeward	11.7 | 19.5
	Leeward rectangular surcharge distance from ridge (ft)	20.5
ASCE 7 §7.7.1	Drifts on lower roofs: Y N	Y
ASCE 7 §7.8	Drifts adjacent to roof projections and parapets: Y N	N
ASCE 7 §7.9	Sliding snow: roof slope and surface roughness	7.6° | S
ASCE 7 §7.10	Rain-on-snow surcharge load (psf)	n/a
ASCE 7 §7.11	Ponding analysis required: Y N	Y
ASCE 7 §7.12	Snow loads on existing roofs: Y N	N
ASCE 7 §7.13	Snow loads on open-frame equipment structures: Y N	N

*IBC 2024 and ASCE 7-22

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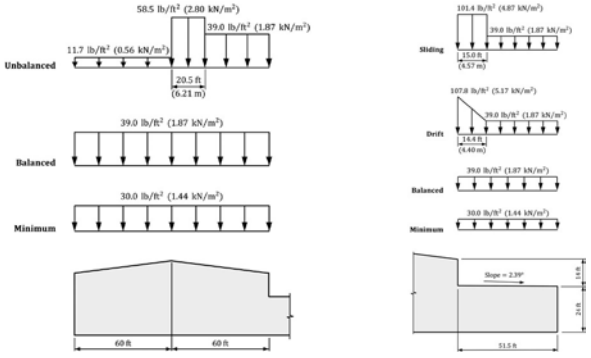
EXAMPLE

Design Snow Loads



Ex 4.7

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APPLICATION

5. The winter wind parameter, W_2, is used to calculate what?

a) Roof temperature
b) Drift height
c) Rafter length
d) Surface roughness

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Snow Provisions Change Summary

1. Ground snow loads, p_g, are based on building risk category
2. Winter wind parameter, W_2, is new for drift height calculations
3. Conversion to allowable stress design ground snow loads, $p_{g(asd)}$, still required for use with some IBC tables
4. Thermal factors, C_t, are now given based on ground snow load and insulation R value of the roof

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Atmospheric Ice Loads

Nominal ice thickness is now based on risk category

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CODE CHANGE

§ 1614.1

Atmospheric Ice Loads

General. *Ice-sensitive structures* shall be designed for atmospheric ice *loads* in accordance with Chapter 10 of ASCE 7.

Exception: *Temporary structures* complying with Section 3103.6.1.5.

- New exception for temporary structures

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CODE CHANGE

§ 2.3.3 & 2.4.3

Load Combinations

Strength Design	ASD
2b. $1.2D + 1.6L + 0.2D_i + 0.3S$	1b. $D + 0.7D_i$
4c. $1.2D + L + D_i + W_i + 0.3S$	2b. $D + L + 0.7D_i$
4d. $1.2D + D_i$	3b. $D + 0.7D_i + 0.7W_i + 0.7S$
5c. $0.9D + D_i + W_i$	7c. $0.6D + 0.7D_i + 0.7W_i$

D_i = weight of ice
W_i = wind on ice

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CODE CHANGE

§ 10.2 & 10.3

Definitions and Symbols

ATMOSPHERIC ICE GEODATABASE: The ASCE database (version 2022-1.0) of geocoded nominal ice thickness, concurrent wind, and concurrent temperature data.

t = Nominal ice thickness on a cylinder caused by freezing rain at a height of 33 ft, from Figures 10.4-2 through ~~10.4-6~~ 10.4-5, for the applicable risk category, in.

- ASCE Hazard tool provides values (asce7hazardtool.online)
  - Based on risk category
  - Free resource

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Design Process for Atmospheric Ice Loads

§ 10.8

Step	Procedure
1	Determine nominal ice thickness, t, concurrent wind speed, V_c, and concurrent temperature for the site from the following: • ASCE/SEI Figures 10.4-2 through 10.4-5, 10.5-1, 10.5-2, 10.6-1 and 10.6-2 • asce7hazardtool.online • Site-specific study
2	Determine height factor, f_z
3	Determine site topographic factor, K_{zt}
4	Determine design ice thickness, t_d
5	Determine ice load, D_i, based on cross-sectional area, A_i, or volume, V_i, of glaze ice
6	Determine wind velocity pressure, q_z, for concurrent gust speed, V_c
7	Determine structure's fundamental natural frequency, n_1, and corresponding gust-effect factor, G
8	Determine wind force coefficients, C_f
9	Determine wind-on-ice load, W_i

Adapted from *Structural Load Determination: 2024 IBC and ASCE/SEI 7-22* – McGraw Hill

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CODE CHANGE

§ 10.4.1

Ice Load

Ice ~~Weight~~ Load The ice load shall be determined using the ~~weight~~ volume or cross-sectional area of glaze ice formed on all exposed surfaces of structural members, guys, components, appurtenances, and cable systems. On structural shapes, prismatic members, and other similar shapes, the cross-sectional area of ice shall be determined by

- Structural shapes, prismatic members, and other similar shapes

$$A_i = \frac{\pi t_d}{12}\left(D_c + \frac{t_d}{12}\right) \quad (\text{ft}^2)$$

- Flat plates and large three-dimensional objects such as domes and spheres

$$V_i = \frac{\pi t_d}{12} A_s \quad (\text{ft}^3)$$

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CODE CHANGE

§ 10.4.2

Nominal Ice Thickness, *t*

The nominal ice thickness is the equivalent radial glaze ice thickness. Figures 10.4-2 through ~~10.4-6~~ 10.4-5 show the ~~equivalent uniform radial~~ nominal ice thicknesses, t, of ~~ice caused by~~ from freezing rain, at a height of 33 ft, over the contiguous 48 states and Alaska for ~~a 500-year mean recurrence interval~~ Risk Categories I, II, III, and IV. ~~Also shown are concurrent 3-s gust wind speeds.~~ Ice thicknesses for Hawaii~~, and for ice accretions caused by other sources in all regions,~~ shall be obtained from local meteorological studies.

- Maps based on risk categories
- Also available from asce7hazardtool.online

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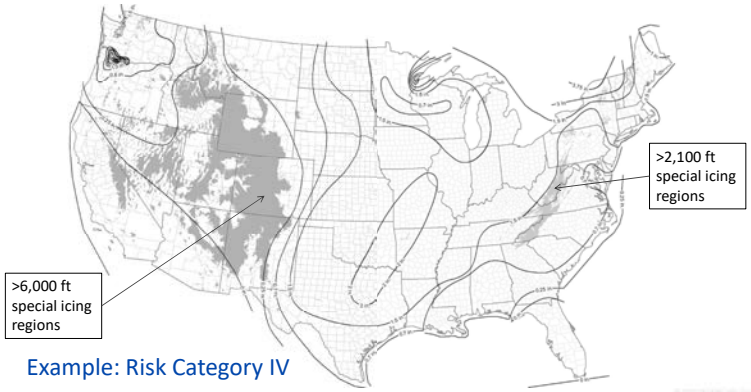
CODE CHANGE

F 10.4-2D

Nominal Ice Thickness, *t*



Example: Risk Category IV

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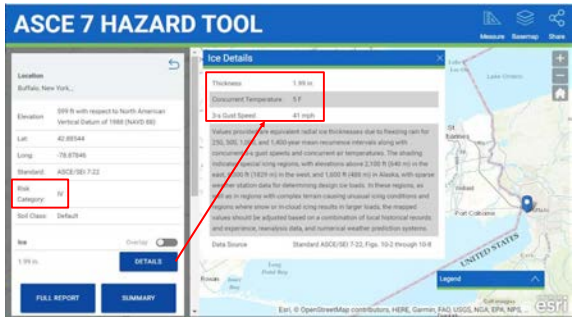
EXAMPLE

Atmospheric Ice Loads Supplemental Data Request



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CODE CHANGE

§ 10.4.5

Design Ice Thickness for Freezing Rain, t_d

The design ice thickness, t_d, shall be calculated from Equation (10.4-5).

$$t_d = t I_i f_z (K_{zt})^{0.35}$$

- Importance factor dropped
- f_z and K_{zt} unchanged
  - K_{zt} = topographic factor from wind loads chapter (10.4.4)
  - f_z = height factor (10.4.3)

$$f_z = \begin{cases} \left(\frac{z}{33}\right)^{0.10} & \text{for } 0 \text{ ft} < z \le 900 \text{ ft} \\ 1.4 & \text{for } z > 900 \text{ ft} \end{cases}$$

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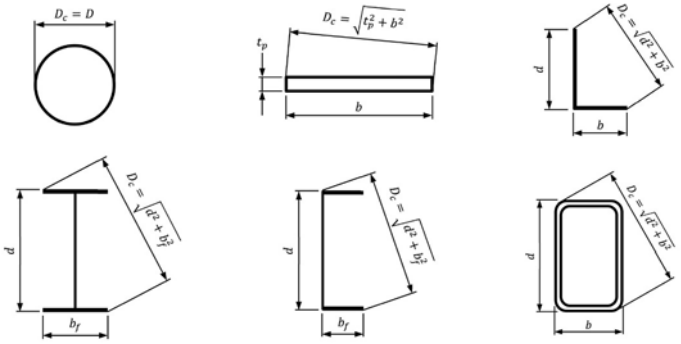
F 10.4-1

Diameter of Circumscribed Shape, D_c



Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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CODE CHANGE

§ 10.5

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Wind on Ice-Covered Structures

Ice accreted on structural members, components, and appurtenances increases the projected area of the structure exposed to wind. The projected area shall be increased by adding t_d to all free edges of the projected area. Wind loads on this increased projected area shall be used in the design of ice-sensitive structures. Figures ~~10.4-1 through 10.4-6~~ 10.5-1 and 10.5-2 ~~include~~ show 3s gust speeds at 33 ft above grade that are concurrent with the ice loads caused by freezing rain. These gust speeds shall be used with nominal ice thicknesses for all risk categories. Wind loads shall be calculated in accordance with Chapters 26 through 31, as modified by Sections 10.5.1 through 10.5.5.

- Add design ice thickness, t_d, to free edges of projected area
- Concurrent gust speeds, V_c, for all risk categories
- Calculate wind loads per Chapters 26 - 31

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CODE CHANGE

§ 10.5

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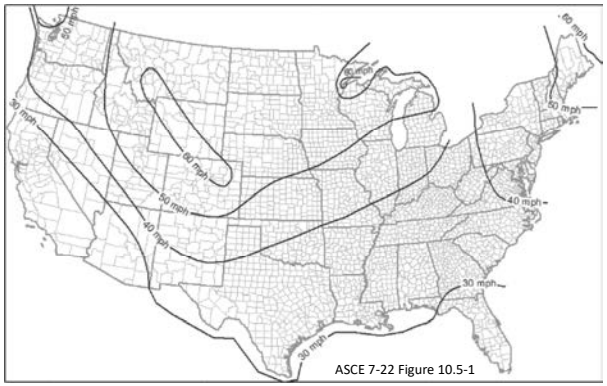
Gust Speeds, V_c, Concurrent with Ice



ASCE 7-22 Figure 10.5-1

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EXAMPLE

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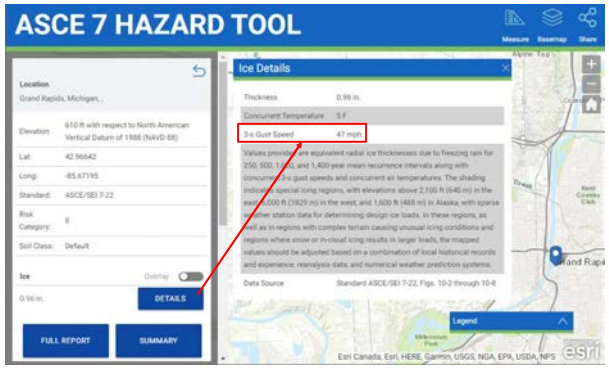
asce7hazardtool.online



82

EXAMPLE

Ex 4.14

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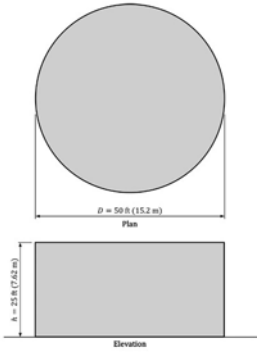
Atmospheric Ice Loads on a Tank

- Material: Reinforced concrete
- Location: Grand Rapids, MI
- Surface Roughness: B
- No hazardous, toxic or explosive materials
  - Risk Category II
- Natural fundamental frequency, n_1 > 1Hz



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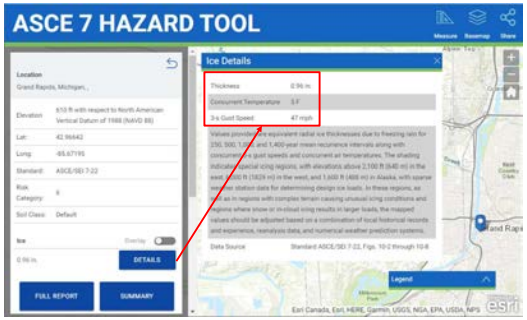
EXAMPLE

Atmospheric Ice Loads Supplemental Data Request



85

85

EXAMPLE

Atmospheric Ice Loads Supplemental Data Request

References*	Atmospheric Ice Load Parameters (IBC 1614.1)	Data
IBC 1604.5	Risk Category: I, II, III, IV	II
asce7hazardtool.online	Nominal ice thickness (in.), t	0.96
asce7hazardtool.online	Concurrent temperature, °F	5
ASCE 7 §10.4.3	Height factor, f_z	0.97
ASCE 7 §10.4.4	Topographic factor, K_{zt}	1.0
ASCE 7 §10.4.5	Design ice thickness (in.), t_d	0.93
	Ice load, D_i, based on glaze ice (plf)	
ASCE 7 §10.4.1	Area: $D_i = A_i$ x density	683
ASCE 7 §10.4.1	Volume: $D_i = V_i$ x density	

*IBC 2024 and ASCE 7-22

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EXAMPLE

Wind on Ice Loads Supplemental Data Request

References*	Wind on Ice Load Parameters	Data	
ASCE 7 §10.5	Concurrent gust speed, V_c (mph)	47	
ASCE 7 §26.6	Wind directionality factor, K_d	1.0	
ASCE 7 §26.11	Structure's fundamental natural frequency, n_1, and corresponding gust-effect factor, G	>1	0.85
ASCE 7 Eq 26.10-1	Wind velocity pressure, q_z or q_h (psf)	3.2	
	Wind force coefficients and wind-on-ice load *(lb)*	C_f	W_i
ASCE 7 §10.5.1 & Eq 29.4-1	Chimneys, tanks and similar: $W_i = q_z K_d G C_f A_f$	0.7	2395
ASCE 7 §10.5.2 & Eq 29.3-1	Solid freestanding walls and signs: $W_i = q_h K_d G C_f A_s$		
ASCE 7 §10.5.3 & Eq 29.4-1	Open signs and lattice frameworks: $W_i = q_z K_d G C_f A_f$		
ASCE 7 §10.5.4 & Eq 29.4-1	Trusses towers: $W_i = q_z K_d G C_f A_f$		
ASCE 7 §10.5.5 & Eq 29.4-1	Guys and cables: $W_i = q_z K_d G C_f A_f$		

*IBC 2024 and ASCE 7-22

$$q_z = 0.00256\, K_z\, K_{zt}\, K_e\, V_c^2 \qquad (26.10\text{-}1)$$

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ASCE 7 Ice and Wind-on-Ice Provisions Change Summary

1. Nominal ice thickness is based on risk category – concurrent gust speed is not
2. Add design ice thickness, t_d, to free edges of projected area to determine wind-on-ice load, W_i
3. MWFRS loads are calculated per Chapters 26 and 29
4. Wind-on-ice loads, W_i, are used concurrently in load combinations with ice weight, D_i

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APPLICATION

6. Concurrent gust speed, V_c, is based on risk category of the structure?

a. True
b. False

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APPLICATION

7. Nominal ice thickness, *t*, is based on risk category of the structure?

a. True
b. False

90

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Resources

Available for use or that can be used for support or help

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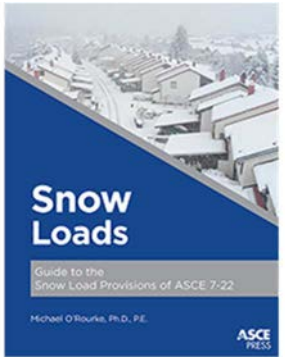
Snow Loads Guide

- Ground, flat and sloped roof snow loads
- Partial and unbalanced loads
- Drift on lower roofs and roof projections
- Sliding snow loads
- Rain-on-snow surcharge
- Ponding instability
- Significant changes to ASCE 7-22
  - GSL and drift load provisions
  - Open framed equipment support structures
  - Snow loads for solar paneled roofs
- Worked examples
- FAQs



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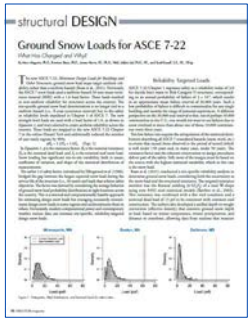
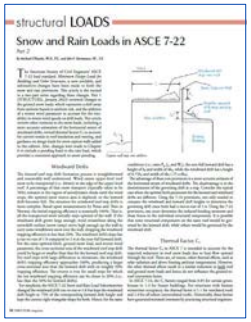
STRUCTURE Magazine Articles


structural DESIGN

Ground Snow Loads for ASCE 7-22


structural LOADS

Snow and Rain Loads in ASCE 7-22


structural LOADS

Snow and Rain Loads in ASCE 7-22

structuremag.org – Jan, Feb, Mar 2022

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